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First Approach to Study the Presence of Domesticated Camelids (*Lama glama*) in the Chaco-Santiago Region, a Marginal Zone of the South Central Andes

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ABSTRACT We analysed bone remains of camelids from the Maquijata site, assigned to the late pottery-making and farming stage (*ca*. 800–400 BP), in order to differentiate between domestic and wild species in the Chaco-Santiago archaeological region. This region is considered marginal to the Argentine Northwest regarding its cultural development and has received less attention than other regions. South American camelids have been one of the major resources in this continent, with domestication recorded in the South Central Andes at around 4400–3000 BP. We applied osteometric techniques and multivariate statistical analyses to proximal phalanges; the results showed interspecific differentiation of archaeological specimens, though with some methodological application issues. These results are the first contribution regarding the presence of domesticated animals in the study area. Copyright © 2012 John Wiley & Sons, Ltd.

Key words: Lama glama; p Lama guanicoe; osteometrics'; multivariate analyses; Chaco-Santiago region

Introduction

The Central-South Andes comprise the high altitude zones of northern Chile, northwestern Argentina, Bolivia and southern Perú (Figure 1 A). This area is considered by several authors (e.g. see discussion in Nuñez, 1981; Olivera & Elkin, 1994; Mengoni Goñalons & Yacobaccio, 2006) as an independent center of camelid domestication, which would have taken place between 4400 and 3000 BP. In turn, the area represented by northwestern Argentina comprises the regions or subareas of *Puna*, *Selvas Occidentales* (Western Forests), *Valliserrana* (Valleys and Hills) and *Chaco-Santiagueña* (Chaco-Santiagan) (González, 1979). For the Valliserrana subarea, the presence of *Lama glama* becomes evident around 2500–2000 BP (Izeta, 2008; Yacobaccio, 2010).

The history of archaeological research in the Argentine northwest shows a biased trend regarding the importance attributed by researchers to different regions; in this sense, the Valliserrana and Puna regions have been considered more relevant, whereas the others have been relegated. This is evidenced by the lack of research about the Chaco-Santiago area during some periods, which has resulted in some information gaps (Togo, 2004). The lesser importance of the Chaco-Santiago region compared to the Valliserrana one is due mainly to the absence of monuments or stone buildings and the relatively 'lesser stylistic development' of pottery in the former area, whereas these characteristics have been abundantly studied in the latter region. In this sense, the Chaco-Santiago region is considered as a marginal zone in terms of its cultural development (Togo, 2005), which was affected by waves of influence or convergence from neighboring regions giving rise to a particular cultural context in this territory (e.g. Hauenschild von, 1943; Bleiler, 1948; Lorandi, 1977; Gramajo de Martínez Moreno, 1978; Togo, 2004). The area studied in the present work is located within the Chaco-Santiago archaeological region and corresponds to the current province of Santiago del Estero, in north-central Argentina (Figure 1 B and C). In this region, following the pioneer work of Cione *et al*. (1979), the study of archaeofaunal remains has started receiving more attention in the last five years (del Papa & Togo 2009), and many authors have already proposed the presence of

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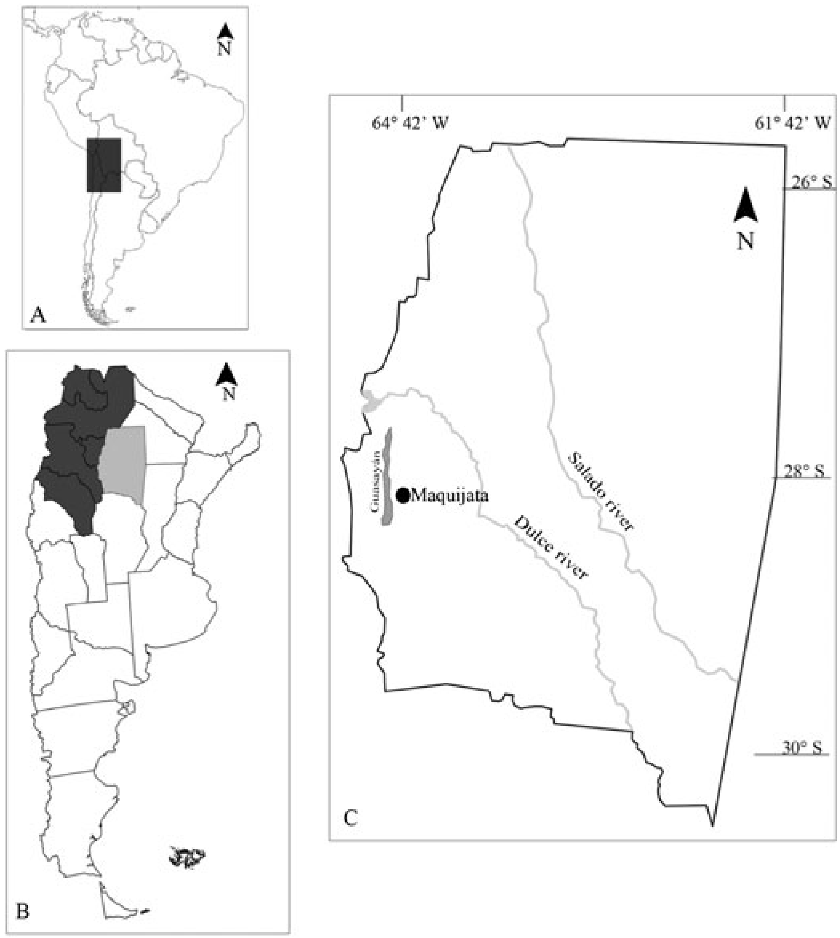

Figure 1. A- Map of South America, with South Central Andes area highlighted; B- Map of Argentina, Argentine Northwest highlighted; C- Map of Santiago del Estero province showing location of the Maquijata site.

domesticated camelids. However, this has never been confirmed by an adequate or systematic analysis of the skeletal remains found.

South American camelids have been the most important resource for hunter–gatherer societies for most of the Holocene (e.g. Wheeler Pires-Ferreira *et al.*, 1976; Mengoni Goñalons, 1995; Elkin, 1996; Miotti, 1998; Olivera, 1998; Politis *et al.*, 2011; Martínez & Gutiérrez, 2004), especially *Lama guanicoe*, a species with wide distribution in diverse habitats of South America, ranging in latitude from 8° to 55° S, and occurring from sea level to 5200 m asl (de Lamo, 2011). On the other hand, *Vicugna vicugna* is adapted to high altitude environments (Puna, at over 3,700 m) of Peru, Argentina, Chile and Bolivia (Franklin, 1982). The first evidences of camelid domestication (probable presence of *Lama glama* and *Lama pacos*) occur in archaeological sites in the Central Andes (central Peru), with most datings ranging between 4600 and 3000 BP with the exception of the site Telarmachay (6000–5500 BP) (e.g. Wing, 1972; Kent, 1982; Wheeler, 1984, 1995; Mengoni Goñalons & Yacobaccio, 2006). For the Central South Andes (probable presence of *L. glama*), similar datings are available, ranging between 4400 and 3000 years BP (Mengoni Goñalons & Yacobaccio 2006). Camelid domestication implied some advantages for these societies, such as resource predictability, availability of meat, fat, hides, fibers, as well as their use as beasts of burden and their significant role in the respective symbologies, rituals and ceremonies; thus, camelids became a primary component of Andean economy and social life (Mengoni Goñalons & Yacobaccio, 2006). The presence of beasts of burden allowed transport and exchange between different ecological zones (transhumance), as well as the dissemination of ideas among different regions. Nevertheless, wild camelids remained relevant for the economy of Andean peoples, through the supply of meat, fat, hides and fibers (Madero, 1993–1994; Yacobaccio *et al*. 1997–1998; Olivera, 1998, among others); even during *Inka* times, the use of wild resources was regulated by usage rules to control overexploitation, and restricted to certain sectors of society, as deduced from chronicles of the time (Cobo, 1553 [1892]).

In this work, we analysed camelid bone remains in order to differentiate domestic from wild species in the archaeological site of Maquijata, department of Choya, located on the eastern slope of the Guasayán hill and at the mouth of the homonymous 'Quebrada' (ravine) (Figure 1 C). To this end, we applied osteometric techniques and multivariate statistical analyses to proximal phalanges. This study focused on proximal phalanges analysis, since these are well represented in the record and are found mostly complete, thus allowing diverse measurements.

Maquijata Site

Maquijata is located 80 km west from the city of Santiago del Estero, in the plains adjacent to Guasayán hill (Figure 1 C). This hill system extends in N-S orientation facing the 'bend of the Dulce river', until Villa La Punta; it is 76 km long and no more than 4 km wide (Ledesma, 1961). The eastern slope rises as an abrupt slope with thick vegetation; in contrast, the western slope is lower. Guasayán hill rarely surpasses 600 masl (Ledesma, 1961). The study site is in the open air, near the eastern slope of this hill.

According to its latitude and longitude, the site is part of the semiarid continental subtropical area. Average temperature in the study area is 20º C, with precipitations (concentrated during summer) that reach 600 mm per year and higher potential evo-transpiration capacity, which results in strong hydric deficit (Ledesma, 1979).

The study area comprises a series of mounds, many of them degraded or reutilized by successive populations that settled in the area. These mounds are variable in size and height, constituting a fairly extensive conglomerate. The presence of a numerous and stable population with stable cultural patterns has been inferred (Togo, 2004). Ceramic materials recovered from the site show elements that have been primarily identified as Sunchitúyoj, and a pottery type characterized by black over bright red coloring or black over red, with hand motifs, associated with the Famabalasto type of Catamarca, which has generally been considered as part of the late stage (Lorandi, 1969; Togo, 2004). In the lowest levels, these are also accompanied by some fragments attributable to Las Mercedes, while in the higher levels, some Averías materials have also been identified (Páez *et al.*, 2009).

Radiocarbon datings were obtained from three sectors of the site, with the oldest one yielding 840 ± 70 years BP (LP- 1487; Sector III, grid 1, level 10–20 cm; plant charcoal); followed by 700 ± 60 years BP (LP- 1719; Sector II, grid 2, level 20–30 cm; plant charcoal); 540 ± 60 years BP (LP- 1707; Sector I, grid 1, level 30–40 cm; plant charcoal); 410 ± 60 years BP (LP-1714; Sector I, grid 1, level 10–20 cm; plant charcoal); and 210 ± 60 years BP (LP-1732; Sector III, grid 2, level 10–20 cm; plant charcoal) (Togo, 2007:231). This latter dating could have been contaminated (Togo, 2007:231).

The context of the site corresponds mainly to the groups that developed Sunchitúyoj pottery. A classical periodization of cultural development (e.g. González, 1963; González & Pérez, 1976; Gramajo de Martínez Moreno, 1978) would assign the groups related to this pottery to the Middle period of the pottery-making and farming period, in relation to the periodization of the Valliserrana area in northwest Argentina, and placed in a sequence above the Las Mercedes materials. Sunchitúyoj can be found contextually associated with Averías materials (considered as part of the Late moment) and lasting until the times of the Spanish Conquest (Gramajo de Martínez Moreno, 1978; Togo, 2004). According to the new radiocarbon datings (Togo, 2007), the Sunchitúyoj materials would correspond to the Late period in the region and their occurrence would span between 1200 and 1500 AD (Togo, 2008). This cultural entity is part of the so-called 'Civilización Chaco-Santiagueña (Rama B)' of the Wagner brothers (Wagner & Wagner, 1934) and of the 'Tradición Cultural Chaco-Santiagueña' of Lorandi (1978) together with the cultural entity Averías (the most recent one); Bleiler (1948) designated it as 'Llajta Mauca bicolor'.

This cultural entity has been traditionally characterized on the basis of the style elements of its pottery, which include bicolor decoration, presence of flat handles and bases, solid conical handles, extensive use of grog and central iconography of the owl in decorative motifs. This cultural entity also comprises bone arrow points, secondary burials of adults in urns, use of nose rings and the inclusion of 'bells' or 'thick pottery' (Gramajo de Martínez Moreno, 1978; Lorandi, 1978; Togo, 2005); some metal elements obtained through Exchange with the Valliserrana area have also been found (Gramajo de Martínez Moreno, 1978). Their pattern of settlement would have been determined by existing water sources, with settlements in the vicinity of the river or its tributaries, forming habitational units on mounds of natural, artificial or mixed origin, both on the plains and on the Guayasán hill system, and variable in size and number (Togo, 2004, 2005). Their pattern of subsistence has been generally characterized as mixed, with strong presence of products obtained from hunting, fishing and gathering, and some contribution from horticulture and probably from camelid domestication (Raffino, 1975; Gramajo de Martínez Moreno, 1978; Togo, 2004).

Background

In the 1930s, the archaeofaunal remains obtained in the region for the studied cultural context were analysed by palaeontologists (Kraglievich & Rusconi, 1931; Rusconi, 1934). In these studies, the camelid specimens were assigned (some with doubts) to different species of this family, including *L. guanicoe* (with two subspecies, *L. guanicoe guanicoe* and *L. guanicoe? lönnbergi*), *Lama? pacos*, *Lama? glama* and even the extinct genus *Paleolama*. These assignations were based on (non explicit) morphological and size criteria, especially to differentiate the specimens of *Paleolama*, although the latter were not subjected to statistical analysis. These determinations have been strongly criticized over time (Bordas, 1940; Parodi Bustos, 1947), mainly in the case of those specimens assigned to extinct taxa, since the goal of the authors was to determine the chronology of settlements on the basis of the fossil association.

In later works, there was no attempt to systematically analyse the differentiation between domestic and wild species, and different authors offered dissimilar interpretations. Some accepted the possibility of animal husbandry (e.g. Palavecino, 1948; Raffino, 1975; Gramajo de Martínez Moreno, 1978; Togo, 2004, 2005), based on documents from the first chroniclers of the region such as Diego Fernández, Pedro Sotelo Narváez & González de Prado (see next section). In contrast, Lorandi and colls. (Lorandi & Lovera, 1972; Lorandi, 1977, 1978; Cione *et al*., 1979), ruled out animal husbandry and instead interpreted the economy of the Santiago del Estero region as mixed, with contributions from agriculture, food gathering, and intense hunting and fishing.

Ethnohistorical sources

The Camelidae represent a particular problem concerning ethnohistorical sources, because this family comprises *L. guanicoe* (guanaco), *L. glama* (llama), *V. vicugna* (vicugna) and *L. pacos* (alpaca), all of which are referred to using the same name 'ovejas' ("sheep") or 'ovejas como las del Perú' ('sheep as those from Peru') without differentiating the species. This makes it difficult to make inferences about the use of these taxa or the activities performed by indigenous groups, because the family comprises both wild (guanaco and vicugna) and domestic (llama and alpaca) species, whose use entails different strategies.

Among the sources that deal with the first contact between Spaniards and natives in this province, we will consider the documents concerning the expedition commanded by Diego de Rojas and, following his death in Santiago del Estero, by his seconds in command (years 1543–1546).

The Probanzas of Pedro González de Prado (1548–1556; Levillier, 1919) are the only documented sources by a survivor of Diego de Rojas' expedition.

> "*...descubrir la provincia de los yuguitas adonde entramos en la dicha provincia donde hallamos mucha comida de maiz y algarroba e chanar y* **muchas ovejas** *donde estaba asentado el dicho real casi un año e nunca nos falto bastimentos*." (Pedro González de Prado 1548–1556 in Levillier 1919: 6)"*...este testigo vido como entraron por fuerza en la dicha provincia e les* **tomaron muchos ganados de ovejas** *y avestruces e pescado e mayz e chanar e algarroba...*" (Pedro González de Prado 1548–1556 in Levillier 1919: 33)

Some other chroniclers refer to Diego de Rojas' expedition, but without having participated in it. Such is the case of Diego Fernández and Pedro Cieza de León.

Fernández (1914) [1571]: 28):

> "**Tienen sus corrales de ovejas como las del Perú**; es gente limpia y bien dispuesta; los bohios que tienen son muy grandes."

Cieza de León (1548–1551 [1877]):

> "*...traen sus mantas largas de lana por debajo del brazo..., en tiempo caluroso tienen de plumas de avestruces hechas otras mantas muy vistosas y galanas.*"(...) "*Sus comidas es maiz* ***e carne de los guanacos é ovejas que tienen...***" (Chapter 91, pp: 318).

These sources indicate the presence of domesticated camelids ('*ovejas*' ['sheep']). Diego Fernández refers to the use of corrals; however, it should be taken into account that this chronicler did not take part in the expedition, and therefore it is difficult to ascertain the source of his information. Cieza de León seems to differentiate between the presence of '*guanacos*' (wild) and '*ovejas*' (domesticated).

We also consider later documents that refer to the early stages of consolidation of Spanish domain on the territory (1583–1605) on the basis of the foundation of the first 'cities' in northwestern Argentina. The consolidation of the Spanish conquest was achieved through founding of cities and settlement of Spaniards, mainly in areas considered as strategic in terms of resource appropriation. However, these first stages of domination included only a few Spanish settlers, organized around the *encomienda* system. These *encomiendas* were managed by a few 'citizens' that were the *encomienda* grantees or *encomenderos*, and native workers or *encomendados*; the latter had to pay tribute to the *encomendero*, usually in the form of labor and production of both food and manufactured goods.

Narration by Pedro Sotelo de Narváez (1583) [1885]: 144)

> "Vestíanse los varones de plumas de avestruces, con que se tapaban sus vergüenzas, y unas mantas las mugeres muy pequeñas, **que hacian de cierta paja y de lana de algún ganado que tenían de la tierra, como lo desta del Piru**"

> "Esta tierra es abundante de pastos, y asi tienen **muchas cazas** y aves, como son liebres, venados, ciervos, **guanacos**, conejos, avestruces,..."

> "Por otra parte tambien hay indios que sirven a Santiago que entran en el número dicho. Viven en la sierra, la cual tiene falta de aguas... Es gente de más razon **y tiene más ganados de los dichos, como los del Pirú**."

Father Alonso de Barzana (1594 [1885], appendix III: LVI).

> "Tienen mucha caza de venados, puercos del monte; **hay vicuñas y guanacos como en el Pirú**."

Something that should be taken into account regarding the documents from this period is the fact that due to the greater contact between societies, and to the way that cities were organized based on *encomiendas*, in which the native peoples were forced to pay tribute, the latter's manner of managing their resources changed due to the fact that they were dominated. Among others, these changes included greater predominance of agricultural and animal farming activities, especially for products from Spain such as goats, sheep, horses and swine; production of fruit trees; cultivation of wheat, barley, chickpeas, garlic, onion, *etc*.

Both Sotelo de Narváez and Barzana mention guanacos in their lists of hunted species. Moreover, Sotelo de Narvaez alludes to the possibility of llama breeding when he states that they had "*...lana de algún ganado que tenían de la tierra, como lo desta del Pirú*."; although this assignation does not seem to be fully reliable at least for the plain area, it becomes stronger for the Sierras region "*tiene más ganados de los dichos, como los del Pirú*.". The presence of llamas could have been reduced, perhaps due to the presence and breeding of European cattle to pay tributes, although its probable presence or absence cannot be ruled out with respect to the early sources.

Differentiation of species through osteometrics

In the case of the camelid family, as pointed out by diverse authors (e.g. Pollard & Drew, 1975; Tonni & Laza, 1976) it is not possible to distinguish among the different species from the morphology of fragmentary bone remains only. The differentiation among these in the Argentine northwest is given by a size gradient, from largest to smallest: *L. glama*, *L. guanicoe*, *L. pacos* and *V. vicugna* (Elkin, 1996; Yacobaccio *et al*., 1997–1998). In turn, specialized llama 'types' may be distinguished, which have peculiar morphological traits associated to their differential uses; these include the *carguera* or pack llama (for meat production and load carrying), *lanuda* or wool llama (wool production) and "intermediate" type (for both meat and wool production) (Reigadas, 1994). Pack llamas are largest, given their specialized use in the transportation of heavy loads.

The sexual dimorphism of these species does not entail significant size differences; thus, it does not hinder the study of inter-species size differences. In order to distinguish inter-species size differences, we performed osteometric studies and applied multivariate statistical analyses (e.g. Menegaz *et al*., 1988; Menegaz *et al*., 1989; Yacobaccio *et al*., 1997–1998; Izeta, 2006, 2007.

Osteometry has developed in recent years, and diverse type of analyses have been applied for its interpretation. The multivariate method (Menegaz *et al*., 1988; Menegaz *et al*., 1989; Yacobaccio *et al*., 1997–1998; Cardich & Izeta, 1999–2000; L`Heureux, 2005, 2007; Izeta, 2006, 2007; Izeta & Cortés, 2006; Izeta & Scattolin, 2006), in which more than two variables are represented for a given element, is the approach that yields best information about the relationships among these variables (size and shape) and the one that can provide a better perspective about species differentiation with greater accuracy and discrimination (Grant, 2010).

A series of difficulties should be taken into account when using this type of analysis; among these, the comparison of recent standards with the archaeological record assumes that both were under the same environmental and nutrition conditions, but the latter may have been different in the past; also, vast periods are unknown in which selection and change could have taken place (Cartajena *et al*., 2007). Archaeological samples are generally fragmented, and therefore obtaining the studied variables depends on the preservation of the samples (fragmentation, meteorization, burnt pieces, predator activity, *etc*.) (Elkin, 1996). Furthermore, one of the conditions necessary to measure specimens is that their ossification centers should be completely fused (fused elements, 'adult' age) (Elkin, 1996). Lastly, some statistical problems may arise in the treatment of data due to the few available reference (standard) samples; the lack of information about intraspecific variation may result in error and areas of intersection (in the statistical results) among species (Cartajena *et al.*, 2007)

Methods and materials

For this work, we analysed camelid remains from the archaeological record obtained through systematic excavation of 10 cm thick artificial levels in two 4 m² quadrats, located in the sectors identified as I and III (Togo, 2004).

A total of 3340 remains were recovered; these correspond to diverse taxonomic categories (including bone fragments, teeth, eggshells and mollusk shell fragments). Quadrat 1, corresponding to Sector I, yielded faunal materials in levels 1, 2 and 4; Quadrat 2, from Sector III, yielded remains in levels 1 to 6, though with fewer elements in the last three levels.

Taxonomic determination

Diverse levels of taxonomic inference were achieved; it was possible to determine seven species of mammals (*Chaetophractus vellerosus, Puma concolor, Pseudalopex gymnocercus, Dolichotis patagonum*, *Pediolagus salinicola*, *Lagostomus maximus* and *Calomys callosus*) and one bird (*Rhea americana*), while for other groups, the determinations reached supraspecific categories: genera *Spixia, Chelonoidis, Tupinambis, Lama, Mazama* and *Ctenomys*; subfamilies Caviinae, Dolichotinae and Sigmodontinae; families Characidae, Dasypodidae, Canidae, Cervidae; suborder Caviomorpha; orders Siluriformes, Anura and Artiodactyla; and classes Gastropoda, Osteichthyes, Aves and Mammalia.

Of the 16 taxa represented at the site, only eight show evidences of having been consumed (del Papa *et al.*, 2012); among these, camelids are the dominant taxon (Figure 2) with a number of identified specimens of 678 and minimum number of individuals of 13.

For the species-level differentiation of camelids, osteometric variables were measured and later analysed using multivariate statistical methods. Due to the scarcity of some elements and the difficulties encountered when measuring some variables in fragmented elements (radius-ulna, humerus, femur, scapula, metapodials), this study focused on the analysis of proximal phalanges, since these are well represented in the record and are found mostly complete, thus allowing diverse measurements. However, only less than a third of the total amount of elements (9 out of 33 available bones) could be included in the analysis, because of their diverse state of fusion or fragmentation.

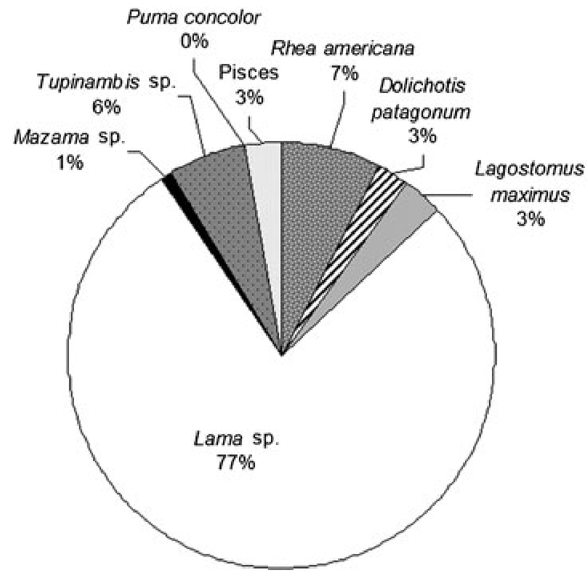

Figure 2. Number of identified specimen % of taxa with evidences of anthropic use.

These were discriminated into forelimb (four items) and hindlimb (five items) classes following Kent's (1982) morphological criterion, given that the differences in size between these kinds (forelimb phalanges are larger) may produce superposition of values among different species if this discrimination is not made (Cardich & Izeta, 1999–2000; L' Heureux, 2005; Izeta, 2006).

For this analysis of camelid remains, and taking into account the geographical location of the study area, the presence of alpaca and vicugna was ruled out given the environmental requirements of these two species; this also helped to reduce 'noise' in the statistical analysis. Alpacas are adapted to *bofedal* habitats (high-altitude marshy vegas) with humid soils (Yacobaccio *et al.*, 1997–1998) and vicugnas inhabit high-altitude (*puna*) environments at over 3,700 masl (Franklin, 1982). Additionally, it is clearly noticeable that the archaeological cases group together with large-sized camelids such as *L. guanicoe* and *L. glama* (Figure 3).

Measurements were taken using digital Vernier-type calipers with 0.01-mm accuracy. To reduce intra-observer variation, each measurement was taken three times, and the mean of these values was used as the final measurement. Measurements taken in millimeters were standardized by log-transformation.

Variables measured: Measurements follow Elkin (1996).

1. Maximum length: measured in parallel to the major axis, using as baseline a line tangent to the surface of the plantar surface proximal condyles and the distalmost point of the distal articular surface, 1FA1

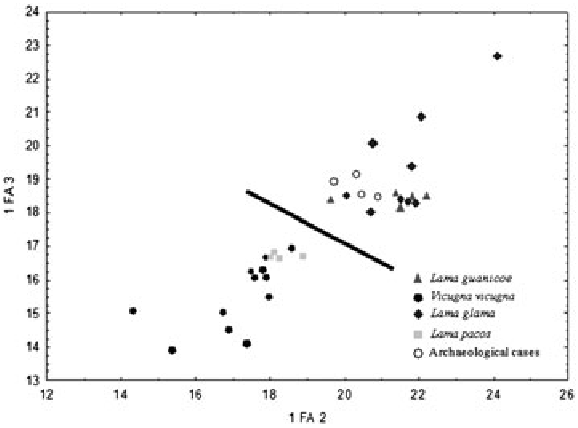

Figure 3. Bivariate graph. Differentiation between the small size and large size group of camelids from forelimb proximal phalanges.

(Elkin, 1996), equivalent to FP1V1 (Kent, 1982) and LM (Menegaz *et al.*, 1988).

2. Maximum width of proximal articular surface: measured latero-medially in the horizontal plane on the highest margin of the articular surface perimeter, 1FA2 (Elkin, 1996), taken from Kent (FPIV2, 1982), equivalent to von den Driesch's (1976) BFp.
3. Thickness of the proximal end: measured in a plane perpendicular to Measurement 2, using as baseline, the proximal (plantal or volar) condyles and measuring on the highest edge of the articular surface perimeter, 1FA3 (Elkin, 1996), equal to FP1V3 (Kent, 1982), Dp (von den Driesch, 1976) and DAPEP (Menegaz *et al.*, 1988).
4. Maximum width of distal end: taken at the widest (volar or plantar) portion of the articular surface, 1FA4 (Elkin, 1996), FP1V4 (Kent, 1982), Bd (von den Driesch, 1976), DTED (Menegaz *et al.*, 1988).
5. Thickness of distal articular surface: measured perpendicularly to the previous measurement, using as baseline a line tangent to the plantar or volar trochlea and measuring along the dorso-volar or dorso-plantar plane, 1FA5 (Elkin, 1996), equivalent to FP1V5 (Kent, 1982) and DAPED (Menegaz *et al.*, 1988).

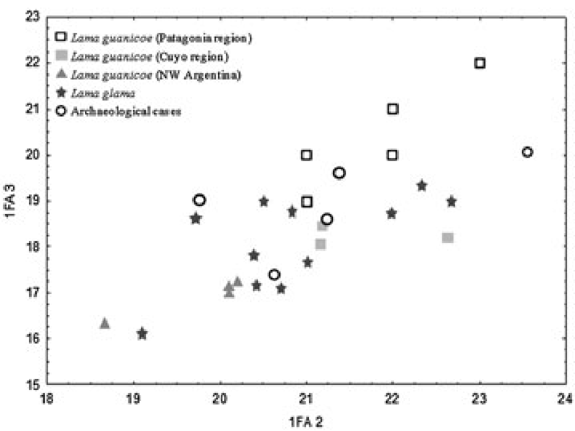

Figure 4. Bivariate graph. Overlapping due to latitude related intraspecific differences from hindlimb proximal phalanges.

As standard (actualistic) measurements, we used the ones taken by Mengoni Goñalons and Elkin (Mengoni Goñalons, pers. comm.) for guanaco from Salta; llama from Jujuy (pack, mixed-purpose and wool varieties; Yacobaccio, 2009 pers. comm.) and llama and guanaco from Catamarca measured by Izeta (2004). These standards were chosen because they correspond to specimens from northwestern Argentina, a region that probably had an influence on camelid domestication practices in our study area. Moreover, the incorporation of guanaco standards from other areas (e.g. Cuyo, Patagonia) resulted in a rather extensive value overlapping due to latitude-related intraspecific differences (Figure 4) (Izeta *et al.*, 2009). Aditionally, some measures taken on llamas of unknown origin from the Jujuy area were also added to our sample (Izeta *et al.* 2009). Measurements for the archaeological samples are given in Table 1.

Table 1. Measurements for archaeological cases

Forelimb proximal phalanges	1 (1 FA1)	2 (1 FA2)	3 (1 FA3)	4 (1 FA4)	5 (1 FA5)
Mj52	72.99	20.88	18.49	17.18	15.66
Mj54	68.23	19.7	18.92	16.17	15.09
Mj73	68.95	20.46	18.57	17.24	15.69
Mj47	68.67	20.31	19.15	16.58	16.43
Hindlimb proximal phalanges	1 (1 FA1)	2 (1 FA2)	3 (1 FA3)	4 (1 FA4)	5 (1 FA5)
Mj51	67.00	23.55	20.07	18.40	16.22
Mj60	65.67	21.23	18.57	16.27	15.53
Mj86	71.44	21.38	19.60	17.61	16.56
Mj67	66.70	19.76	19.01	16.22	16.18
Mj22	62.54	20.63	17.39	15.79	14.70

Bivariate graphs were used to observe size tendencies of specimens; the variables used for these graphs were maximum width of proximal articular surface (1FA 2) and thickness of the proximal end (1FA3). This tool allows us to assign each specimen to a particular group, by distributing measurement pairs in a cartesian plane.

The multivariate statistical analyses included principal component analysis (PCA) as well as cluster analysis using unweighted pair group using arithmetical averages) and Manhattan distance similarity coefficient (e.g. Menegaz *et al*. 1988, 1989; Izeta 2004, 2007); they were performed using the statistical software package PAST (Hammer *et al*. 2001). PCA allows to separate measurement groups by vectors to minimize the differences between the members of a same group and maximize differences between groups (Cartajena Fasting, 2009). The cluster analysis generated a similarity matrix that expresses numerically the phenetic relationships between each pair of phalanges studied (Menegaz *et al*. 1988). Using these analyses, samples can be segregated by shape and size, and then be compared with predetermined taxonomic categories (Cartajena Fasting 2009).

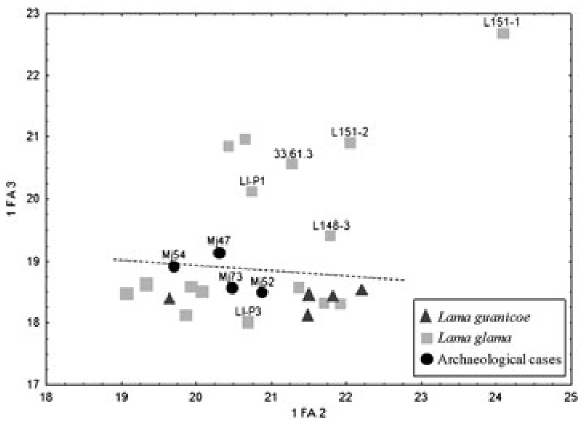

Figure 5. Bivariate graph. Forelimb proximal phalanges.

Results

Forelimb proximal phalanges

The bivariate graph (Figure 5) shows that even when some elements belonging to diverse living species do overlap, there is a section occupied only by *L. glama* specimens, without any *L. guanicoe* elements. This can be observed in a line drawn on the graph, mainly from 1 FA 3 variable. The archaeological samples fall within the overlapping zone.

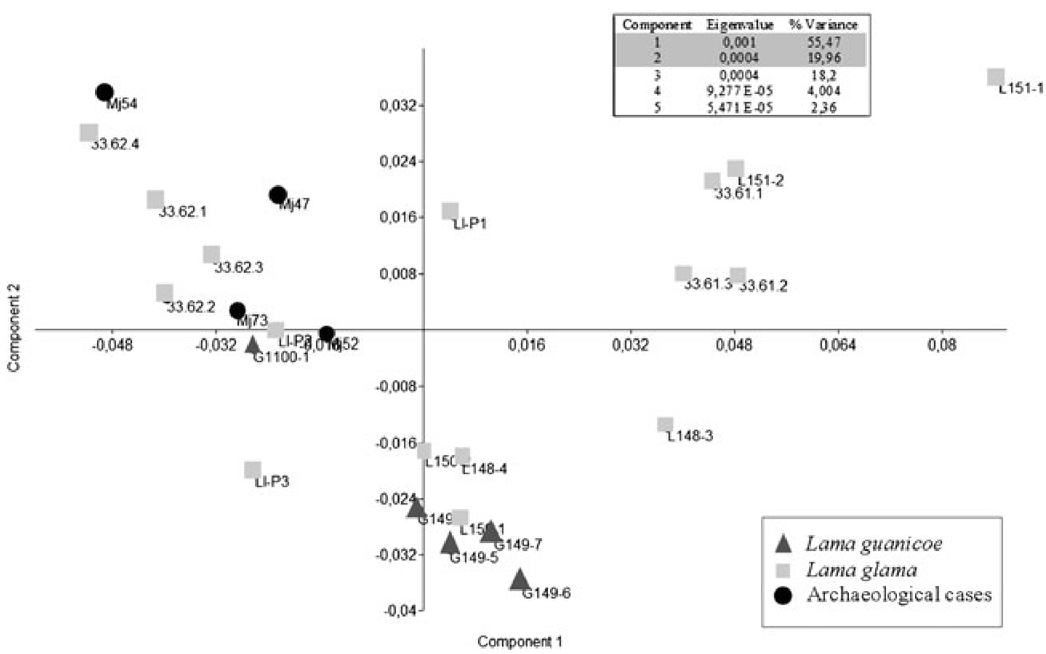

Figure 6. PCA of forelimb proximal phalanges.G1100-1: Measurements from guanaco (*L. guanicoe*), Salta. Taken by Mengoni Goñalons and Elkin (Mengoni Goñalons, pers. comm.)Ll-P1: Measurements from pack llama (*L. glama*) from Pozuelos, Jujuy (Yacobaccio) (pers. comm.)Ll-P2: Intermediate-type llama (*L. glama*) from Pozuelos, Jujuy (Yacobaccio) (pers. comm.)Ll-P3: Wool llama (*L. glama*) from Pozuelos, Jujuy (Yacobaccio) (pers. comm.)G149: Measurements from guanaco (*L. guanicoe*), Catamarca (Izeta 2004)L148, L150, L151: Measurements from llama (*L. glama*), Catamarca (Izeta 2004)33.61.1; 33.61.2; 33.61.3; 33.62.1; 33.62.2; 33.62.3; 33.62.4: Measurements from llama (*L. glama*), unknown place of origin (*Izeta et al*. 2009)Mj47; Mj52; Mj54; Mj 73: Archaeological samples, Maquijata site

The PCA for forelimb proximal phalanges (Figure 6) shows an overlap between specimens of living species. Nevertheless, the specimens of *L. guanicoe* are more clustered while *L. glama* presents greater variation. Most archaeological cases cluster in a group that distributes close to five *L. glama* specimens and one *L. Guanicoe* individual, but assignation to either species is difficult.

The cluster analysis for forelimb proximal phalanges (Figure 7) also shows that some *L. glama* elements are associated with certain *L. guanicoe* elements and not to the remaining cases of the same species, which may somewhat hinder the interpretations regarding interspecific differentiation. With respect to the archaeological cases, Mj 52 is closely associated with a llama specimen (L 148–4)

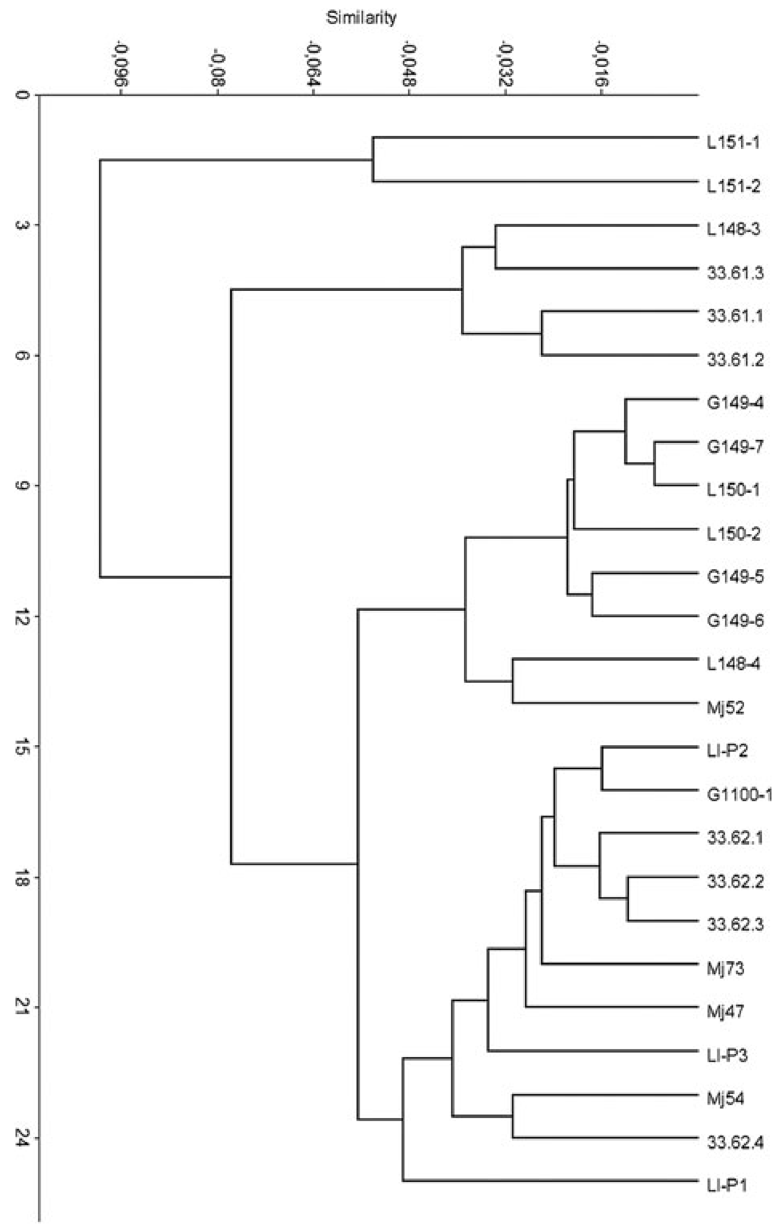

Figure 7. Cluster analysis of forelimb proximal phalanges.G1100-1: Measurements from guanaco (*L. guanicoe*), Salta. Taken by Mengoni Goñalons and Elkin (Mengoni Goñalons, pers. comm.)Ll-P1: Measurements from pack llama (*L. glama*) from Pozuelos, Jujuy (Yacobaccio) (pers. comm.)Ll-P2: Intermediate-type llama (*L. glama*) from Pozuelos, Jujuy (Yacobaccio) (pers. comm.)Ll-P3: Wool llama (*L. glama*) from Pozuelos, Jujuy (Yacobaccio) (pers. comm.)G149: Measurements from guanaco (*L. guanicoe*), Catamarca (Izeta 2004)L148, L150, L151: Measurements from llama (*L. glama*), Catamarca (Izeta 2004)33.61.1; 33.61.2; 33.61.3; 33.62.1; 33.62.2; 33.62.3; 33.62.4: Measurements from llama (*L. glama*), unknown place of origin (*Izeta et al.* 2009)Mj47; Mj52; Mj54; Mj 73: Archaeological samples, Maquijata site

and is secondarily associated with a group of llama and guanaco (G 149 and L 150). The elements Mj 47 and MJ 73 are associated with a group integrated for four llamas (33.62.1, 33.62.2, 33.62.3 and Ll-P2) and one guanaco (G 1100–1). Mj 54 is closely related to a llama specimen (33.62.4) and then to the previously discussed group.

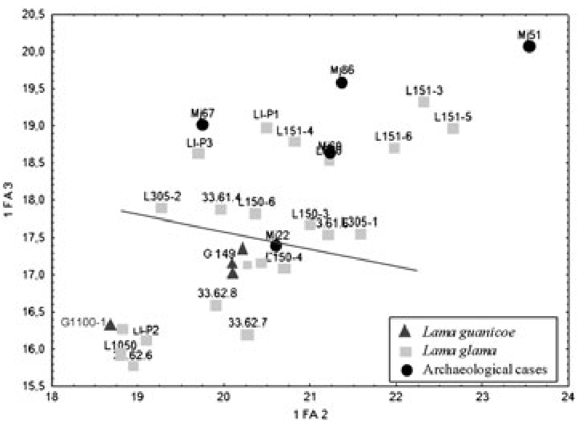

Figure 8. Bivariate graph. Hindlimb proximal phalanges.

Hindlimb proximal phalanges

For the hindlimb proximal phalanges, the bivariate graph (Figure 8) shows a more marked tendency when compared to the forelimb phalanges. Even though there is some overlap between elements belonging to diverse living species, clear separation of a portion of space occupied only by *L. glama* specimens, without any *L. guanicoe* elements, can be observed from the line drawn on the graph.

PCA (Figure 9) shows that as in the previous analysis, *L. glama* presents greater variation, with some overlap with *L. guanicoe* cases. In this analysis, the archaeological cases are clearly associated with specimens of the living *L. Glama* and, among the former, Mj 86, 51, 60 and 67 are close to the pack llama specimen (Ll-P1). Mj 22 is associated with a group of living *L. guanicoe* specimens, although other llama elements would also be associated with this group.

In the cluster analysis for hindlimb phalanges (Figure 10), although groupings can be seen between cases of *L. glama* and *L. guanicoe* with not all cases being grouped by species, there seems to be greater ordination among the latter cases.

Regarding the archaeological samples, Mj 67 is clearly grouped together with the pack llama (Ll-P1),

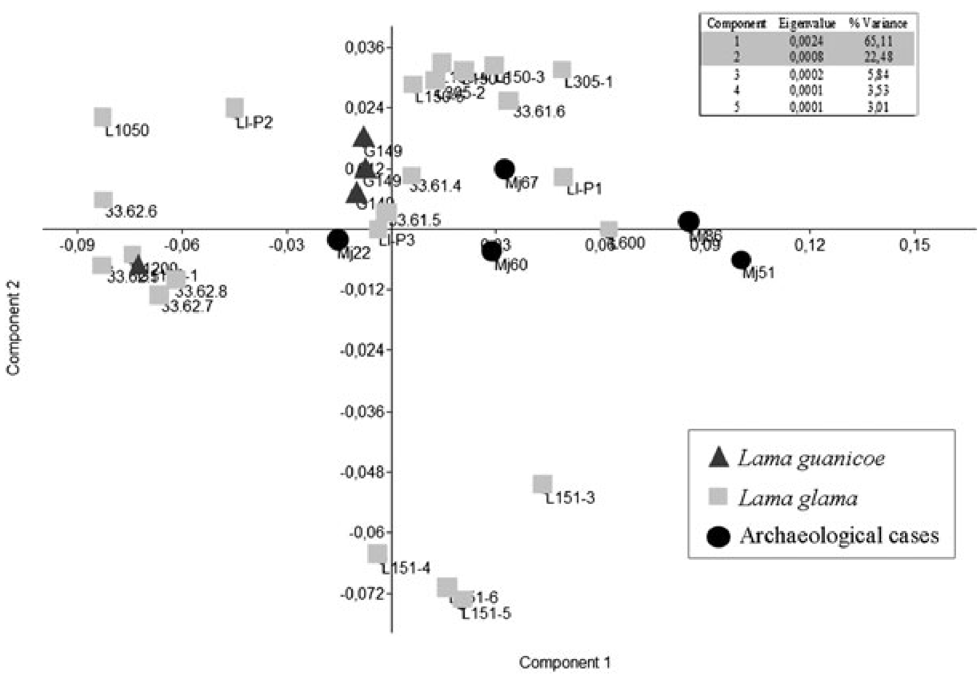

Figure 9. PCA of hindlimb proximal phalanges.G1100-1: Measurements from guanaco (*L. guanicoe*), Salta. Taken by Mengoni Goñalons and Elkin (Mengoni Goñalons, pers. comm.)Ll-P1: Measurements from pack llama (*L. glama*) from Pozuelos, Jujuy (Yacobaccio) (pers. comm.)Ll-P2: Intermediate-type llama (*L. glama*) from Pozuelos, Jujuy (Yacobaccio) (pers. comm.)Ll-P3: Wool llama (*L. glama*) from Pozuelos, Jujuy (Yacobaccio) (pers. comm.)G149: Measurements from guanaco (*L. guanicoe*), Catamarca (Izeta 2004)L150, L151: Measurements from llama (*L. glama*), Catamarca (Izeta 2004)L1050; L305-1; L305-2: Measurements from llama (*L. glama*), Jujuy (in Izeta *et al*. 2009)L1200; L600; 33.61.4; 33.61.5; 33.61.6; 33.62.5; 33.62.6; 33.62.7; 33.62.8: Measurements from llama (*L. glama*), unknown place of origin (in *Izeta et al*. 2009)Mj51; Mj60; Mj86; Mj67; Mj22: Archaeological samples, Maquijata site

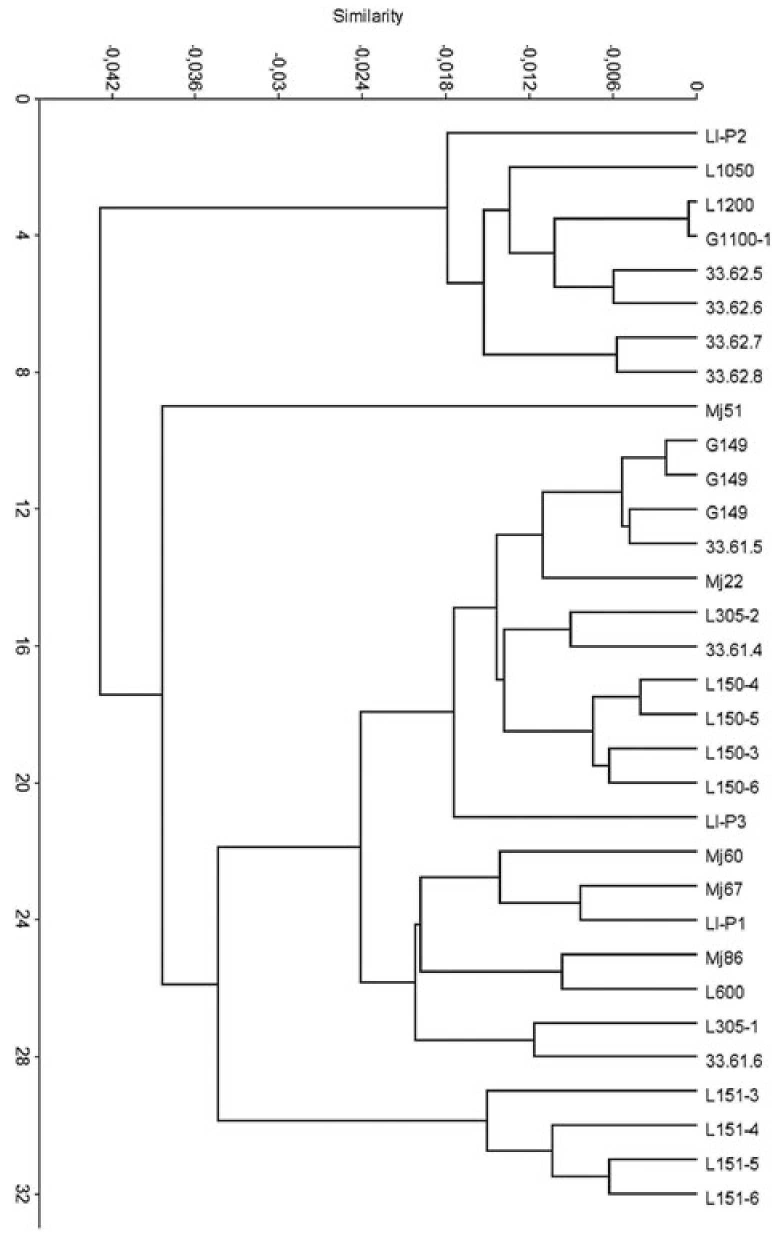

Figure 10. Cluster analysis of hindlimb proximal phalanges.G1100-1: Measurements from guanaco (*L. guanicoe*), Salta. Taken by Mengoni Goñalons and Elkin (Mengoni Goñalons, pers. comm.)Ll-P1: Measurements from pack llama (*L. glama*) from Pozuelos, Jujuy (Yacobaccio) (pers. comm.)Ll-P2: Intermediate-type llama (*L. glama*) from Pozuelos, Jujuy (Yacobaccio) (pers. comm.)Ll-P3: Wool llama (*L. glama*) from Pozuelos, Jujuy (Yacobaccio) (pers. comm.)G149: Measurements from guanaco (*L. guanicoe*), Catamarca (Izeta 2004)L150, L151: Measurements from llama (*L. glama*), Catamarca (Izeta 2004)L1050; L305-1; L305-2: Measurements from llama (*L. glama*), Jujuy (in Izeta *et al*. 2009)L1200; L600; 33.61.4; 33.61.5; 33.61.6; 33.62.5; 33.62.6; 33.62.7; 33.62.8: Measurements from llama (*L. glama*), unknown place of origin (in *Izeta et al*. 2009)Mj51; Mj60; Mj86; Mj67; Mj22: Archaeological samples, Maquijata site

as is Mj 60. The three elements are associated with the group formed by Mj 86 and three specimens of *L. glama* (L 600, L 305–1 and 33.61.6). Mj 22 is related to a group of three specimens of *L. guanicoe* (G-149) and one *L. glama* (33.61.5). Element Mj 51 is related to a great group gathering especimens of *L.* glama and *L. guanicoe* whit greater dissimilarity distance; this differentiation can also be observed in the bivariate graph and PCA. Elements Mj 51 is larger than the living standards, as can be observed in the bivariate graph (Figure 7) and PCA, considering the first principal component as a size estimator (Figure 9). In this case, this morphotype could be represented by those archaeological specimens larger than those of living *L. glama*.

Discussion and final comments

This analysis by means of osteometry and multivariate statistics is intended to help differentiate between species; however, this approach only allows assessment of a trend in specimen size (López, 2008). In the case of archaeological elements, interpretation of such analyses may be difficult because conditions such as nutrition status, environmental factors or occurrence of hybrids are unknown (Cartajena *et al.*, 2007). Our systematic inferences for specimens found at archaeological sites based on this type of study are only approximations. Until more information becomes available about the ways in which the abovementioned conditions could have affected the populations of these species, the results only indicate whether the archaeological cases are similar to those corresponding to living camelid species.

Some problems of taxonomic assignation remain, due to the absence of significant size differences between *L. glama* and *L. guanicoe* (Cartajena *et al.*, 2007). It is evident from the analysis performed in this work that intraspecific differences play an important role in differentiation, as there are overlapping values between these two species and the separation between *L. glama* and *L. guanicoe* is not always clear (Figure 6 and 7 especially).

In this study, the comparison of hindlimb proximal phalanges allowed better differentiation between morphotypes (Figures 9 and 10) than the analysis of forelimb proximal phalanges (Figures 6 and 7), in contrast with the results obtained by Izeta *et al.* (2009). In the case of forelimb phalanges, it was possible to assign two archaeological element to *Lama* cf. *L. glama*, while in the remaining cases, no distinction was possible, and they were consequently classified as llama-guanaco (with values similar to those of both species). For the hindlimb phalanges, we were able to assign three archaeological specimens to *Lama* cf. *L. glama*; one elements that – due to their larger size – differed from living species were assigned to *Lama* cf. *L. glama* and other specimen could also be classified as llama-guanaco.

One way to respond to the temporal and spatial circumstances of a region is through the domestication of animals, ensuring permanent availability of the latter during annual and seasonal cycles, and thus increasing the predictability of these resources (Olivera, 1998; López, 2002), exploiting both primary products (meat, fat, bone marrow and bones), and secondary byproducts (use as means of transport and for ceremonial practices); by means of selection, breeding control, feeding and protection from predators (Reitz & Wing, 1999).

In the study area, domestication would be an activity incorporated within a model of resource complementarity (generalist strategy) that also includes items obtained by means of hunting, fishing, gathering and agriculture/horticulture, to achieve a more adequate and balanced diet and thus reduce the risk and cost to the populations that inhabited the area at a time (pottery-making and farming stage) when the latter were relatively large and stable (so as to not surpass the carrying capacity of their environment).

This work represents the first systematic approximation to the presence of domestic animals in the Chaco-Santiago region and contributes to the inferences made by other researchers on the basis of, often confusing, ethnohistorical data. In this area, where no indications of the so-called Archaic[1] period have been found so far (Togo, 2004), it is possible that camelid domestication resulted from the dispersal of ideas or animals after years of active exchange with populations of the Central-South Andes; in this sector, camelid domestication would date from 4400–3000 BP (Mengoni Goñalons & Yacobaccio, 2006). Therefore, the first domesticated camelids were probably brought in our region of study by the first sedentary populations, represented by the societies bearer of 'Las Mercedes' and 'Candelaria' pottery, around 350 AC. 'Las Mercedes' would have matrices that come, on one hand, from the Tafí-Candelaria cultures and, on the other hand, from Cienaga-Alamito-Condorhuasi (cultures of the Valliserrana region); finally, there is the possibility of a common origin for all of them (Togo, 2007). Both, the presence of farmyards – as mentioned in the ethnohostorical sources (Fernández (1914) [1571]: 28) – and the finding of possible guano layers in the archeological sites of this region (Greslébin, 1932) would suggest active camelid breeding in our region. However, it must be noticed that Diego Fernández did not participate in Diego de Rojas' expedition (he's not a direct witness) and that the possible guano layer has also been interpreted by other authors (i.e. Togo, 2004) as some collapsed roofing remains from ancient housings. In that sense, it would be relevant to perform new studies looking for farmyards, as well as more conclusive indicators of camelid breeding.

The pressence of domesticated camelids in the studied region would help us understand the complex net of social relationships that developped between neighbour regions before the arrival of the Spanish colonizators and their relevance as means of transporting objects. An example of this would be the pressence –in different moments of the cultural development of Santaigo del Estero – of metals (coming from the Valliserrana region), thick pottery or 'Campana' (from the Eastern regions of the Paraná basin) and sea mollusks coming from the Atlantic coast, more than 1000 km away. Also, a close relationship can be seen between Chaco-Santiagueña and Valliserrana regions in later times, as it is demonstrated by the presence in the latter of pottery of Santiago del Estero origin (Sunchitúyoj y Averías).

Notes

Archaic Period: time of transition to production of food including plants and animals.

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